JOHNS HOPKINS
Center for Environmental
& Applied Fluid Mechanics

# Weekly CEAFM Seminar: Spring 2013

Date: **Friday, April 12, 2013**

Time: 11:00 AM

Location: Gilman 50 (Marjorie M. Fisher Hall)

Speaker: **PROF. SÁNDOR KOVÁCS** (Washington University in St. Louis)

Title: ***"HOW YOUR HEART WORKS WHEN IT FILLS: AN ENGINEERING PERSPECTIVE"***

## Abstract

The two engineering principles that govern the diastolic (filling) phase of all human hearts are "constant volume pump" and "suction pump."

The approx. 850 ml volume of the pericardial sac decreases by only approx. 40 ml by end systole. This requires that atrial-ventricular volumes simultaneously reciprocate and it underscores the pressure pump (systolic) and volume pump (diastolic) roles of the coordinated function of the chambers. Of the 4 heart chambers ONLY the left ventricle actually serves as a (systolic) pressure pump. When the normal left ventricle initiates filing at mitral valve opening, it generates only a small (4mmHg) maximum atrio- ventricular pressure gradient (LVP< LAP) while LV pressure continues to decrease for about 100 msec while LV volume increases (dP/dV< 0). Because the chamber recoils faster than it can fill it is a suction (volume) pump. The purpose of diastole is to fill the chamber (mass transfer in two phases) in the fraction of a second available in order to maintain cardiac output. Suction initiated filling allows the chamber to return to its equilibrium (diastatic) volume. The streamlines entering through the 5cm2 mitral valve rapidly form an asymmetric toroidal vortex whose formation time has been shown to depend on LV chamber parameters of stiffness, relaxation and load. Recent Lagrangian coherent structure (LCS) analysis of MRI data of vortex ring growth in the LV reveals nature's elegant fluid mechanics based solution to the diastolic mass transfer problem. The intraventricular vortex also "rinses" the trabeculated inner surface of the heart thereby preventing formation of blood clots and facilitates mitral leaflet coaptation to minimize mitral valve regurgitation.